Provisional Patent Application

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Title: **Remote Camera Relay Controller and Docking Apparatus**

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Abstract

A remote camera relay and docking apparatus comprising a portable enclosure for attaching a hand-held digital camera thereto and comprising communications means for transparently relaying control signals and image data between the digital camera and a distant processor. Data rate conversion and error correction coding are included for providing reliable, low power communications without the need for flow control or handshaking. The processor operates the digital camera remotely over a communications channel such as a dial-up telephone network, an infra-red link or a wireless RF link. In one configuration, the communications means comprises a modem for exchanging control and image data between the camera and distant processor. The digital camera attaches to the relay apparatus by means of a standard camera mounting screw. In another configuration, the digital camera attaches within a weather-resistant case which contains the relay communications electronics, electrical signal interfaces for connecting the digital camera thereto and a power source. Power management is also provided for maximizing operating time when used in low power, portable, battery operation.

Background

This disclosure relates to remote digital camera operation which receives camera commands and transfers digital photographs to distant locations by combining the arts of digital camera technology and communications methods. In many applications there is a need to control camera functions and to view the resulting photographs from distant locations such as in

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viewing construction site progress, surveillance of unoccupied residences, vacation property, boats and any other application where visual observation from a distant location is desired.

Commercial digital camera products, which store images in memory as data rather than as optical images on film, are becoming widely available. In these devices, image data is captured into RAM, flash memory or floppy disk whereby the electronic image data becomes immediately accessible after a picture is taken. Although many digital camera products provide an LCD display for instant image monitoring, in general the data must be transferred from the camera to a computer, printer or other type of controller in order to view the images. As such, digital camera products typically include a communications interface in order for the data to be transferred or uploaded to a receiving device. An application program run on a computer controls several camera functions including the transfer of image data from the camera to the computer, image editing and image storage. Some application programs allow for control of the camera shutter function and also for the deletion of images stored in the camera.

Typically, the computer and camera are collocated in practical use. Control of a digital camera by application software is generally done by a direct connection between the computer serial port and the camera communications port. Such a connection is highly reliable since the camera and computer are in close proximity, use a physical wire connection between the devices and involve a simple data exchange between a single source and a single destination.

The use of modems for transmitting digital data over a phone line is well known. Modems commonly interface to a computer by means of a serial interface known as an RS-232 or more recently Universal Serial Bus (USB), which defines a standard communications protocol including data formats, data rates and voltage levels which encapsulate the raw data. The modem converts the serial data into a signal compatible with the particular phone service being used, then transmits the signal over the medium. In addition to conventional analog phone services, direct digital and wireless telephony are rapidly becoming available in an assortment of communications products.

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Several types of image telephony devices exist. These include video phones, video teleconferencing products and digital cameras directly connected to a computer for subsequent modem or LAN transmission. Remote video image devices connected directly to a computer has many disadvantages for field use. First, a collocated computer is a relatively expensive installation, especially if it is used only for a remote imaging function. Second, a remote, collocated computer requires significant power which does not lend itself to continuous field use under battery operation for extended time periods. Third, a remote field computer must be made to withstand various weather conditions which would significantly add to cost. Fourth, the aggregate combination of a computer, modem and camera requires separate, bulky components which doesn't lend itself to a portable efficient integration.

SUMMARY

The remote camera relay controller method and apparatus provides an interface and relay between a remotely located imaging input device such as a digital camera and a local computer or controller. The apparatus allows for a connection between camera and computer, but instead of a conventional serial port interface between the computer and digital camera, the relay apparatus remotely forwards data through a communications link. Camera and computer interface signals are regenerated after passing through the link, thereby establishing a virtual interface between end-points.

The addition of communications forwarding devices between the remote camera and host processor introduces several problems. These include data rate incompatibilities, data overflow and the introduction of bit errors, which don't exist in a collocated camera-computer configuration. In order to provide reliable, seamless communications, the relay controller performs data rate compensation by means of rate conversion, provides data formatting, establishes link communications, provides error control, forwards image data, sends and receives control data.

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For general purpose operation, the camera relay operates independently of specific camera data protocols. It does this by transparently streaming data between the camera and host computer without depending on handshaking or flow control with the relay controller apparatus. In order for this to be achieved, two critical constraints must be satisfied. First, clock timing inaccuracies that normally occur between the different communications nodes must be compensated for. Second, data flow through the relay must be sufficiently error-free in order not to interfere with the normal data exchange expected between end point devices.

A communication method is herein disclosed which takes advantage of the inherent asymmetrical characteristic of information flow in the use of digital imaging in general. In contrast to a typical bi-directional communications channel wherein the data rates and information size are more or less equal, a digital camera involves small amounts of data traffic in one direction but large amounts in the other. The command and control signals into the camera which trigger camera functions such as shutter release, delete photo or get-image only take a few bytes. Transferring the image data in the opposite direction, from the camera to the host computer however, takes from tens to hundreds of thousands of bytes depending on image resolution and image compression algorithms employed.

The remote camera relay controller apparatus addresses the problem of data rate incompatibilities caused by close but unequal end-to-end baud rates during on-line operation by taking advantage of the digital camera data asymmetry. It does this by using rate conversion means to step up the data rates at each node when image data is transferred from the camera back to the host. This method effectively eliminates overflow conditions and the need for flow control or handshaking. Each of the receive nodes in the communications chain passes the camera image data on to the next node at a higher rate than received. Stepping up the rate in one direction would necessarily cause a down stepping in the opposite which would normally impact reliable communications in this direction. Due to the extremely low command and control traffic from host to camera, data flow in this direction becomes insensitive to rate down stepping. This concept will be further developed in the following sections.

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The remote camera relay controller also performs ancillary control functions such as receiving command scripts from the host, remotely downloading a schedule of camera events and autonomously issuing camera commands at programmed times. In addition, the relay apparatus has the ability to autonomously initiate and establish communications and to relay camera image data back to the host.

Objects and Advantages

An object of the disclosed invention is to provide for a small, portable and robust integration of camera and communications components to effectively function as a single remote imaging and communications unit, but also to allow for the separate and independent operation of the digital camera when the relay controller is not attached.

Another object of this invention is to allow the use of the disclosed relay controller as an add-on option to commercially available digital cameras thereby offering a remote, unattended imaging capability to digital cameras. This would greatly lower the cost of a remote imaging capability since the camera would have a dual use as a conventional camera.

Another object is to provide a method for a general purpose remote image relay device which transparently interconnects a commercial digital camera to a local host viewer without the need for communications flow control or handshaking.

Another object is to apply low power communications methods and error correction coding for transmitting remote camera images to a receiver.

Another object of this invention is to provide a weather-resistant enclosure comprising wireless communications means in which a commercial digital camera can be inserted and protected from the elements.

A further object is to provide a low cost, modular, remote image relay means by using the image acquisition and storage capabilities of a commercial digital camera within the communications relay enclosure.

Still further, this disclosure presents a method and apparatus for passing image data from a remote digital camera to a local controller without the need of a collocated computer at the remote location.

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Yet another object of the disclosed apparatus is to allow for the relay controller to accept schedules and camera control scripts over the communications link and to operate autonomously by automatically taking photos in accordance with said control script.

It is also an object of the disclosed apparatus to provide efficient power management using rate conversion and signal processing methods so that the digital camera can operate for extended time periods in a portable, battery operated configuration.

Description of Drawings

Fig 1A shows a modem configuration of the remote relay controller in relation to an external digital camera attachment.

Fig 1B shows a wireless communications configuration of the remote relay controller in relation to a digital camera attachment.

Fig 2A shows a modem configuration of the remote relay controller which encloses a digital camera.

Fig 2B shows a wireless communications configuration of the remote relay controller which encloses a digital camera.

Fig 3A is a high-level block diagram of an embodiment of the remote camera relay and its relationship to communications with a host computer.

Fig 3B shows a high-level block diagram of the remote relay controller using data rate converter and modem.

Fig 3C shows a detailed block diagram of the data rate converter using Error Correction Coding.

Fig 4 is a block diagram of the remote relay controller in a wireless forwarding system configuration.

Figs 5A to 5E show detailed block diagrams of various operational modes of the digital relay controller electronics.

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Principle of Operation

A digital camera is used to take photographs, but unlike ordinary film, the images are stored electronically as digital data. In order to view the images, the digital data is generally uploaded to a computer by means of a serial interface. Communications with the connected camera is generally established by an asynchronous serial data format where bytes are transmitted along with overhead bits at known standard data rates. Asynchronous communications can also provide flow control and error checking.

Vendor proprietary protocols are often used when exchanging commands, acknowledgments and data between the camera and the computer application software. The specific formats of the command strings and image data vary from product to product, however the fundamental camera operations are consistent. These included shutter control, image deletion and uploading of images. Power on/off control and record/play control are sometimes not accessible from the serial interface. In this case manual operations must be performed by depressing physical switches on the camera The record/play switch allows the camera to take pictures in the record mode and to view photos in the play mode. Manual switching helps to prevent inadvertent recording and powering but as a result, requires means other than the communications interface to operate these functions.

Many digital cameras are available which can be completely controlled via serial port commands, without the need for manual switch access. An example is the Largan, Inc. Model 350 digital camera which is used as part of the preferred embodiment disclosure. In order to allow for remote control in other digital cameras requiring manual switching, direct access to the switch contact points by the relay controller may be used. A switch can be made to "close" by providing an appropriate voltage to the contact points which mimics the same voltage as that of the manually closed switch. This results in an identical camera response as the manually switched circuit.

One of the functions of the disclosed invention is to reproduce the camera command sequence that would normally appear at the communications interface as if a direct connection to

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a computer were present. Data interface is accomplished by means of a physical connector between the serial port of the digital camera and the relay controller electronics. Some recent digital cameras however, employ an infra-red (IR) link for communicating between the camera and the controlling computer. Without loss of generality, an IR link can be applied to the relay controller as well. As an alternative, or in addition to a serial signal cable or IR link between camera and relay controller, the enclosure can include external signal contact points located at positions that mirror associated contact points on the camera body. Affixing the camera to the relay enclosure mates the contact points and thus establishes electrical communications.

The relay controller includes a capability for differentiating between various types of received data packets. Command packets that are intended for direct control of the camera can be routed directly to the camera interface. Received command and control scripts intended for the relay controller can be recognized and routed thereto. For example, the relay controller can be commanded to store the received command scripts and replay the command scripts at programmed times thereby allowing for autonomous photography operation without direct on-line control. Application software running on the distant processor can be programmed to transmit these different packet types depending on desired functionality.

The disclosed invention provides several communications modes. The first transparently passes a reproduction of the serial signal data that is present at the camera/computer interface through a modem and USART combination. For example, a command byte string sent from the computer serial interface, through the transmit modem will reappear intact at the camera interface after passing through the receive modem and receive USART.

A second mode re-creates the voltage levels at the switch contact points, as described previously. In this mode, unique received command sequences are transformed by the relay controller and then turned into signals that are used to activate the manual camera functions including power on/off and switching between the record and play modes if necessary.

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In a third mode, unique commands are recognized by the controller relay, but ignored by the camera. Once a command is recognized, it triggers the generation of a recreated camera control sequence. Thereby, the transmission of the actual sequence in a real-time collocated computer exchange becomes unnecessary. This mode allows for the relay controller to issue camera command sequences autonomously for direct control of the computer and communications link. This is useful in taking pictures in accordance with a schedule of programmed events.

The operation of the enclosure adds to the overall functionality of this invention. The enclosure has a form-factor which houses the modem, USART, and processing electronics, but also comprises means for attachment of the camera using a standard threaded camera screw mount typically found on photographic equipment. Access to the manual switch contact points is made available to the relay electronics by positioning the contact points on the camera body in locations corresponding to those on the relay enclosure. Pressure on the mating contacts, exerted by tightening the mounting screw, results in the electrical connection therebetween.

A serial communications connector, a modem connector and a power connector are included as ports on the enclosure body. When mounted to a camera, the relay controller invention results in a clean, integrated unit having all cables and connectors neatly arranged. Package size is minimized by use of a modular modem, such as the Cermetek model #1798, and integrated ASIC electronics for providing all electronics processing in a small package, compatible with the size, shape and footprint of the attached camera.

Rate Converter

A key aspect of the remote relay controller is to transparently pass command and image data between the remote camera and the local processor through the modem using minimal hardware processing in the field. In a conventional configuration where the digital camera is directly connected to the computer serial port, a modem is not involved. In this direct interface, a constant baud rate is selected and signal handshaking is sometimes used to insure reliable

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communications. Even without handshaking or flow control, a collocated camera and computer can depend on static baud rates and relatively error-free data transfer without experiencing data overflow or underflow. For example if the computer serial port and the digital camera are both set to operate at 19,200 baud, then data throughput can always be maintained since there is only one sending device and one receiving device; the computer and camera, for example.

With the introduction of a modem within the signal path however, a constant baud rate between each device will result in data loss and render the communications unworkable. This is because of a slight offset between asynchronous clocks in the communications chain. For example, if the digital camera transmits data at 19,200 baud to a send modem, the receive modem may actually be communicating with the local computer at a slightly lower rate due to clock inaccuracies; 19,100 baud for example. In this example, two data forwarding devices are involved; the camera communications port, which transfers data to the send modem and the receive modem, which in turn transfers data to the computer serial port. As commands and image data are streamed between the camera and computer end points, data will be lost due to overflow of image data at the send modem if DCE rates are too low, or at the computer due to USART rate inaccuracies. In contrast, a collocated computer/camera combination has a single data originating device and a single receiver which does not incur an overflow condition.

The remote relay controller solves this problem by providing rate conversion means for stepping up the image data transport rate at each stage. This is done by operating the camera at one rate, setting the modem communications (DCE) rate at a second higher rate and operating the local host processor at a third rate higher than the previous two rates. For example, the rate converter can accept remote camera data at 19,200 baud, accumulate a packet of bits, then transmit the packet to through the modem at 24,000 baud then on to the local host processor at 38,400 baud. A data packet can be a standard USART byte format containing a start bit, eight data bits and a stop bit. Since the data transported at each stage is higher than the previous, there is no chance of overflow at the receiver and a continuous 19,200 baud camera transmission throughput can be maintained indefinitely. The modem DCE communications rate must be set at a rate high enough to accommodate camera data throughput plus the addition of modem protocol overhead data and the occasional retransmission of erroneous modem data packets. Although

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modems negotiate DCE rates depending on telephone channel conditions, in the preferred embodiment the digital camera is set to a default rate of 19,200, the modem DCE rate is set to operate with a minimum data rate of 21,600 and the local host processor is set to a rate of 38,400.

Since the data in the reverse direction must pass through the same electronics as in the forward direction, the data rate at each stage becomes stepped down. Data arriving from the local host computer at a continuous 38,400 baud rate, transmitted through the modem at 21,600 baud and relayed to the camera at 19,200 baud cannot in general maintain a continuous rate without data loss. However, command and control data packets comprise relatively small data packets and are not continuous. For example, in the Largan Digital camera the "take photo" command is only two bytes long. A small buffer in the local send modem and the remote receive modem can easily absorb the bytes transported at the 38,400 baud rate as long as the average data embedded within does not exceed the camera input baud rate and the number of contiguous data bytes does not exceed the buffer capacity.

Rate conversion in the remote camera relay controller includes the operations of stepping up the baud rate in the image transfer direction and stepping down the baud rate in the command and control direction without suffering any loss of information. A key benefit is the ability to transparently perform data transfer through the remote relay without requiring flow control or handshaking. This allows for the use of off-the-shelf digital camera control software to remotely operate a digital camera through the remote relay, without modification.

<u>Rate Conversion for RF Transmit Power Reduction</u>

In a wireless embodiment, the remote camera relay uses an RF link as the communications medium to transfer image data between the remote digital camera and a local host computer. In this configuration a portable, battery operated operation is realized, therefore several factors including battery energy consumption, maximizing reception distance and minimizing radiated power must be considered.

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In most remote viewing applications, there is expected to be a relatively long idle time between snapshots. The null time periods between photos can be taken advantage of by applying signal processing methods to reduce transmitter power, extend reception range, improve reliability and extend battery life. In RF communications systems, it is well known that reliable data reception is dependent on the ratio between transmitter energy-per-bit and electrical noise (Eb/No). Eb/No can be increased by stepping down the camera image data rate, thereby resulting in more energy per bit transmitted.

In contrast to stepping up camera image data rates for the purpose of allowing real-time error-free continuous throughput, a stepped down rate conversion in the RF link can be accomplished by accepting the camera image data at the nominal camera baud rate, buffering the image data in the remote relay controller, then passing the buffered image data at a much lower rate to an RF transmitter. Alternatively, since digital cameras inherently store the captured images in internal memory, the camera could be commanded to output data at its lowest communications port rate, thereby eliminating the need for additional buffer electronics in the remote relay controller. However, to achieve extremely low rates and low power, an external buffer is still required. It is well known to those skilled in the art of communications theory that transmitted power is the rate at which the bit energy in sent. In other words, it takes more power to transmit the same bit energy in a short time period as opposed to a long time period. If the image data captured in the digital camera is forwarded over a long time duration, then significant power can be saved.

As an example, the remote camera relay passes a command to the digital camera to upload a stored image through the serial communications port. The relay receives image data from the digital camera at a nominal 19,200 baud rate and temporarily stores the block of data in a buffer. The image data rate is then stepped down to 2,400 baud and passed on to an RF transmitter for sending the image data to an RF receiver. Alternatively, the digital camera can be commanded to output image data at 2,400 baud, if possible, thereby eliminating the external buffer. The Largan digital camera used in the preferred embodiment however, has a minimum communications rate of 4,800 baud, therefore an additional rate converter must be used to obtain

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2400 baud. At the lower rate, it takes eight times as long to transmit the buffered image data however, this requires only one-eighth the radiated power for transmitting the same bit energy as the 19,200 baud rate. As an alternative to reducing radiated power, the signal can be transmitted at full power at 2400 baud resulting in a 9db energy gain which corresponds to several orders of magnitude improvement in bit error rate performance.

The RF receiver which receives the image data then converts the data to a standard USART signal which could be passed to the input of a local computer for viewing the image. The data can also be buffered, stepped up to a higher rate, 38,400 baud for example, and forwarded through a modem over a telephone line to a distant computer. The on-line connection time is minimized by forwarding the buffered image data, not the real-time 2,400 baud data, at the highest rate possible.

Relay Communications Coding

The expansion of the information bit transmission time of this invention allows for other communications techniques to be applied thereby offering even further advantages and benefits in addition to low power. For example, spread spectrum techniques such as direct sequence modulation could use the time-expanded bits for improved interference rejection. Error correction coding could be applied for decreasing the bit error rate or alternatively providing gain thus further lowering transmitter power. Spread spectrum and Error Correction Coding are widely used in RF communications systems and are well known to those skilled in the art of electronic communications. In the preferred embodiment example that follows, Forward Error Correction (FEC) coding is used in combination with time expansion of data for the purposes of reducing transmitted power, expanding relay controller battery life and increasing the reliability of the communications by decreasing bit-error rate.

In error correction coding, redundant bits are appended to the original information bits in accordance with a given encoding algorithm. In doing so, received bit errors can be detected and corrected by a compatible decoding algorithm before passing the data on for subsequent processing. The fact that bit errors can be corrected at the receiver allows some

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degradation to occur in the RF link without suffering a performance penalty. This implies that a reduction in transmitter power or a reduction in Eb/No can be compensated for by taking advantage of coding gain.

Many different types of error correction codes are available for this purpose, however in the preferred embodiment a Reed-Solomon code is used, due to its high performance and relatively simple encoding which is important for minimizing power and hardware in the remote, portable field unit. Decoding is much more complex however, but decoding is done at the receiver side of the transmission where low power and hardware sizing are not concerns. An example of a Reed Solomon code is the RS(255,191) code which can correct 32 bytes in error out of a block of 255 bytes. This code requires 64 parity bytes to be appended to each 191 bytes of information however, more than 5 db of coding gain is achieved which is equivalent to three-fold extension of transmitter battery life. Summarizing, error correction coding can be used to improve bit error rate performance and to significantly reduce transmitter energy consumption.

Description of Preferred Embodiment

Referring to Fig 1A, an overall view of the remote relay controller in relation to an external digital camera is shown. In this configuration, communications between the remote relay controller and a local processor is accomplished by means of a modem. Digital camera **2** attaches to enclosure **1**, which contains the relay controller electronics and modem, by means of mounting screw assembly **3**. A detail of mounting screw assembly **3** is shown as **3a** which includes a threaded mounting screw **4** on one end and a knurled knob **5** on the opposite end. Knurled knob **5** has embedded therein, a threaded cavity **6** for receiving a reciprocal threaded screw for attachment of an additional mounting device such as a tripod, bracket or the like.

Mounting screw **4** has a standard thread dimension such as that typically used to attach photographic equipment to a tripod stand. Mounting screw assembly **3** passes through enclosure **1** as shown. Attachment of camera **2** to enclosure **1** is accomplished by tightening

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screw 4 with knurled knob 5 into a cavity within the body of camera 2 which has reciprocal threads for accepting screw 4.

Shown in Fig 1A is a connector cable 7, for electrically interfacing the control port of digital camera 2 to the relay electronics contained within enclosure 1. In the modem configuration of Figure 1A, an RJ11 telecommunications receptacle 8, which is typically used for connection of telephone equipment to dial-up phone lines, is used to interface the relay controller modem to communications signals. This is used for interconnecting the relay modem signals to a distant controller over a telephone network.

Also shown on enclosure 1 is a multitude of electrical contact points 9. These are used as additional signal connections between digital camera and relay controller. Contact points 9 make a connection with corresponding contact points on the digital camera body when mounting screw 4 is inserted into the threaded receptacle of the camera body and tightened by turning knurled knob 5. Contact points 9 are pushed against corresponding camera contact points, thereby establishing electrical communications between relay controller and camera.

FIG 1B shows a relay configuration which includes an RF link as an alternative to a modem for establishing communications between the remote relay controller and a local processor. Digital camera 2 attaches to enclosure 1 in an identical manner as that described in FIG 1A. In the RF link configuration of FIG 1B, the camera control and image data signals are modulated onto an RF carrier and passed through antenna 7. In both configurations of FIG 1A and FIG 1B a power connector 11 is shown for supplying external power to the remote relay controller electronics. Internal batteries can alternatively be included within enclosure 1 for operating the electronics.

FIGS 2A and 2B illustrate an alternative embodiment of the relay controller apparatus. In this configuration, digital camera 2 is completely contained within enclosure 12. Figures 2A and 2B correspond to a modem embodiment and RF embodiment, respectively. In FIG 2A, communications signals between the remote relay controller electronics and the local processor are interfaced by means of RJ11 telephone receptacle 17. In FIG 2B, RF signals are passed

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through antenna **18**. Camera **2** attaches to slide rail **13** having a slot **14**, with a threaded mounting screw **15**. Slot **14**, allows camera mounting screw **15** to be positioned at any point along slide rail **13**. This makes it possible to accommodate various camera dimensions and mounting thread locations in order to properly position the camera so that its lens aligns with window **16** as slide rail **13** transports camera **2** laterally into the body of enclosure **12**. This allows photographs to be taken while in the inserted position. Slide rail **13** is retained within enclosure **12** by using common attachment means including friction, mechanical fasteners or the like.

Referring to FIG 3A, a high-level block diagram of the remote camera relay and its relationship to communications with a host computer is shown. In this configuration a remote digital camera **23** receives commands originating from a local host computer **20** through host communications transceiver **21** and remote communications transceiver **22**. Camera **23**, in turn, returns image data as well as command acknowledgments and other status information back to host computer **20** through transceivers **22** and **21**. Host communications transceiver **21** receives data from host computer **20** then modulates the signal onto a suitable carrier for transmitting the data across the transmission medium where it is received by remote communications transceiver **22** before being passed on to digital camera **23**. Transceivers **21** and **22** could be a pair of dial-up modems, wireless modems, RF link, infra-red link or any other means for transporting data signals between dislocated end points. Similarly, in the opposite direction, transceiver **22** receives data from digital camera **23** then modulates and transmits the data to transceiver **21** which demodulates the signal and passes the data to host computer **20**. An example of a camera command and image transfer will now be described.

A camera command to "take a photo" is initiated by application software running on local host computer **20**. The command has been formatted by the camera vendor software in accordance with the protocols required by the specific digital camera being used. A key point here is that it is not necessary for the remote relay controller to know the specific command formats and camera vendor protocols used, since the invention will transparently pass signals across the link thereby reconstructing the correct format at the camera port. It is a known characteristic, however that command packets for controlling camera functions are generally

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very short in comparison to the very large data records returned from the camera. The camera software drivers which are supplied by the vendor, generally conform to industry standards such as Twain, which allows the use of third-party image application software. Although transparent communications allows for the use of vendor products without modification, the use of custom software for digital camera control is not precluded if camera data protocols are known.

Referring to FIG 3B, a short byte sequence which is recognizable by the digital camera is passed out of host computer **20** through a standard serial port where it would normally expect the digital camera to be located. Instead, host modem **24** receives the serial data from host computer **20**. Remote modem **25**, which has established communications with host modem **24**, passes the camera command data to rate converter **26**. The output of **26** is then supplied to the serial communications port of digital camera **23**. Since the command sequence received at the camera communications is identical to that which would have been received if camera **23** had been directly interfaced to host **20**, camera **23** acts on the command and takes a photograph. Depending on the particular digital camera used, camera **23** will then either automatically pass the image data out of its communications port, or else it can be commanded to do so in a similar manner as that just described for taking the photo. In either case, a digital representation of the photo is passed from camera **23**, appropriately formatted by the camera manufacturer, into rate converter **26**. The output of **26** is then passed to modem **25** for transmission of the image data to host modem **24** which then supplies host computer **20** with the demodulated stream of data bytes which are recognizable by the host image viewing software.

The function of rate converter **26** is to step up the data rate in the image transfer direction from remote camera **23** to local host **20**. In this direction, large image data records are involved and it therefore becomes necessary to step up the rate in order to continuously and transparently forward the image data without flow control or handshaking. A typical color digital image having a resolution of 480 by 320 pixels contains from about 30,000 to 100,000 bytes depending on which image compression algorithm is used as part of the camera image format.

In the opposite direction however, commands from host computer **20** to remote camera **23** use the same hardware as in the forward direction and therefore are subject to a

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stepped down baud rate as a result. Normally this would introduce an overflow problem. However, since commands from the host involve only a few number of bytes, the small internal FIFO buffers typically included in modem electronics, can absorb the rate difference. Although stepping up the rate in the image transfer direction is critical to transparent rely controller operation, the rate difference in the command and control direction becomes inconsequential.

In the preferred embodiment, a Largan digital camera is used wherein its default serial port rate operates at 19,200 baud. The image data stream from camera **23** is then passed on to rate converter **26** which steps up the input serial rate from 19,200 to an output rate greater than 21,600 baud, which is the DCE rate configured to be used between host modem **24** and remote modem **25**. Depending on the particular modem used, a limited degree of rate conversion can be performed within the modem if configured in an unconventional manner. The Cermetek model #1798 modem can be configured to accept DTE data at one of several standard baud rates then transmit the data using a different DCE rate. The serial communications port of host computer **20** is configured to send and receive data at a 38,400 rate. The net effect is an asymmetrical data transfer which transmits camera **23** data at 19,200 baud and is ultimately received by host computer **20** at 38,400 baud. In the reverse direction, commands originate at host **20** at 38,400 baud which are ultimately received by digital camera **23** at 19,200 baud.

Remote modem **25** is a commercial Cermetek model #1798 modem which supports a range of modem standards and speeds. It has been selected because of its small size and high functionality. Communications modes can be programmed using the standard AT command set, well known to those skilled in the art of modem applications. The present invention uses several of the modem capabilities including automatic answer and link connectivity. Modem **25** is configured with the following AT command settings which are stored internally to the Cermetek modem in non-volatile RAM:

ACTIVE PROFILE:
B1 E1 L1 M1 N1 Q0 T V1 W1 X4 Y0 &C0 &D0 &G0 &J0 &K0 &Q5 &R1 &S0 &T5 &X0&Y0
S00:001 S01:000 S02:043 S03:013 S04:010 S05:008 S06:002 S07:050 S08:002 S09:006
S10:014 S11:095 S12:050 S18:000 S25:005 S26:001 S36:007 S37:000 S38:020 S44:020
S46:136 S48:007 S95:000

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This configuration allows for modem operation without flow control and without connection to data terminal equipment (DTE) such as a computer. In addition these settings enable modem **25** to automatically answer upon receiving a ring signal. The minimum modem modulation connection rate is set to 21,600 by using the following setting in which V.34 modulation is selected:

AT+MS=11,1,21600,33600

The exchange of modem signals for negotiations and establishment of a data connectivity are standard modem operations which are well known to those skilled in the art of modem communications.

FIG 3C shows a more detailed functional block diagram of rate converter **26** used for stepping up the image transfer rate in a real-time image viewing application. Herein, image data from digital camera **23** of FIG 3B is received by USART **27** which converts the 19,200 baud, serial format of the image data into byte-serial words. The output of USART **27** feeds buffer **28** which accumulates a block of data bytes before forwarding it on at a stepped up rate through error correction encoder **29** to USART **30**. Although not required, encoder **29** in this case performs an error correction encoding algorithm for improving the image bit error rate as detected by a compatible decoding algorithm when received by the host computer. Error correction coding adds redundant bytes to the image data, therefore a code which adds only a small number of overhead bytes must be used in order to maintain a stepped up rate. A Reed-Solomon (255,223) code satisfies this condition. In a minimum configuration, without coding however, only a single byte needs to be buffered since each byte arriving at USART **27** can be immediately transferred through USART **30** at the higher rate. USART **30** will always be ready for data due to a faster output rate than byte arrival rate. Clock **31** feeds divider circuit **32** which supplies USART **27** with a 19,200 baud rate and USART **30** with a rate greater than 21,600 baud.

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Command packets in the opposite direction are received by USART **30** at the negotiated modem DCE rate exceeding 21,600 baud, then pass directly to buffer **28**. Since command packets are short in duration, coding is not required for either power savings or error rate improvement, and is therefore not used. The output of buffer **28** is sent to USART **27** which is stepped down to 19,200 baud before passing on to the digital camera port.

FIG 4 shows a more detailed functional block diagram of the remote camera relay controller as used in a wireless configuration. Herein, an RF link is used to relay camera commands and image data between the remote digital camera and a forwarding dial-up modem, which in turn communicates with the host computer. In this case, the rate conversion function steps *down* the image transfer rate (instead of up as in the previous discussion) for a different purpose. In the RF link, baud rate limitations and overflow conditions due to interface timing differences, are not an issue. A stepped down image data rate can significantly reduce transmitted power and also improve bit error performance.

Image data from digital camera **23** is received by USART **27** which converts the 19,200 baud, serial format of the image data into byte-serial words. The output of USART **27** feeds buffer **28** which accumulates an entire image block which could contain tens of thousands of bytes. The data block from buffer **28** is then input to Error Correction Encoder **29** which segments the data into sub-blocks and adds redundant bytes to each sub-block in accordance with the error correction algorithm being employed. In the preferred embodiment, a Reed-Solomon block code is used because it possesses several favorable attributes including high error correction performance, low overhead and relative simplicity of data encoding. The sub-block size depends on the specific coding format being used however for this embodiment, a Reed-Solomon(255,191) code, which is well known to those skilled in the art of error correction coding, is applied. The encoded data block from **29** is passed on to USART **30** which converts the byte serial words back into a bit serial data stream at a stepped down rate of 2,400 baud. Clock **31** in this case feeds divider circuit **32** which supplies USART **27** with a 19,200 baud rate and USART **30** with a 2,400 baud rate. The output of USART **30** is then passed to remote RF transceiver **38** which modulates the encoded and stepped down image data for transmission to forwarding RF transceiver **35**.

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Transceiver **35** demodulates the received image data and passes it to error correction decoder **36** which performs the Reed-Solomon(255,191) error detection and correction algorithm. Decoder **36** corrects any errors that may have occurred in the RF link, strips off the parity bytes then passes the decoded image data to image buffer **34**. The data in image buffer **34** then passes on to forwarding modem **33** at 19,200 baud rate. The rate conversion in this case is accomplished by controller **37** which is a PIC 17CXXX series microcontroller, which governs the data flow from buffer **34** into forwarding modem **33**. Controller **37** also has an input to RF transceiver **35** for applying spreading and de-spreading pseudo-noise sequences if spread spectrum communications processing is employed. The data output from forwarding modem **33** is transmitted over a dial-up phone network to host modem **24**, then passed on to host computer **20** for viewing images.

Command data originating at host computer **20** passes in reverse through the identical processing chain, with the exception of the error decoding and error encoding functions. Command data from image buffer **34** passes directly to forwarding RF transceiver **35** and the remotely received command data is passed from USART **30** to buffer **28**. As before, coding is not used in the command direction because of the short duration of command packets.

FIG 5A is an implementation block diagram of the remote relay controller electronics, for performing the functions described in association with FIGS 3A-3C and FIG 4. A communications signal which has been properly formatted and transmitted with a send modem by a local processor, is received at the input of modem **41**. The communications signal contains data within having a command protocol consistent with operation of the digital camera. The commands initiated by local processor are identical to those that would pass directly from an application software program to the camera communications port in a conventional collocated computer-camera configuration. A key function of the remote relay controller electronics is to transparently relay the commands to the camera without necessarily having knowledge of its content.

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After establishing modem communications, the modem outputs a standard RS232 signal which is then passed to USART **42** where the RS232 start bit, stop bits and parity bits are removed, resulting in a byte serial format of the received data. The RS 232 signal is a well known communications protocol used frequently for data communications. The output of USART **42** is then passed to correlator-A **45**, data latch-A **46,** correlator-B **47**, data latch-B **48** and also to data selector-A which functions as a crossbar switch in combination with data selector-B **44**. These will each be described.

Commands initiated by the host computer comprise two types of data communications. The first are the packets sent by the camera application program and are intended to be received and operated on by the digital camera. The second are command and data packets intended for receipt by controller **49** included in this embodiment of the relay controller electronics. Unique header bytes are included in the data stream as part of the command packets sent by the host computer which indicate either controller commands or camera commands. The unique header bytes are recognized by correlator-A **45** which then enables data latch-A **46** to hold the subsequent command bytes received from USART **42**. The output of data latch-A **46** then serves as the control signal for data selector-A **43** and data selector-B **44** which govern the selection of signal source and destination between USART **42**, controller **49** and the interface signal from data selector-B **44** to the digital camera.

The bytes that follow then indicate the presence of either camera control packets or relay control packets. If camera control packets are detected, then the signal path which interconnects USART **42** communications directly to the camera serial port is selected (Path I). If command or data packets which are intended for controller **49** are detected, then a connection between USART **42** and controller **49** is established (Path II). A third signal path can be established which interconnects controller **49** and the interface between data selector-B **44** and the digital camera (Path III). This signal path allows for the control of the camera directly by controller **49** rather than through the communications link emanating from the application program at the local computer. This supports autonomous operation of the camera by performing camera command scripts stored in the relay processor. An additional signal path which passes data between USART **43** and controller **49** simultaneously to a connection between

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controller **49** and the output interface of data selector-B **44** can be made (Path II and Path III). This path can be used to include data processing between the digital camera and the forwarded data stream such as the baud rate conversion, Reed-Solomon error correction coding and image data buffering that was discussed in reference to FIGS 3A-3C and FIG 4.

Also shown in FIG 5A are connections between USART **42** to correlator-B and data latch-B **48**. These function in a similar manner as that described for correlator-A **45** and data latch-A **46**, except in this case unique commands are recognized for directly controlling manual switch functions on the digital camera rather than through the camera serial communications port. The manual switch command is passed from data latch-B **48** to signal converter **51** which translates the command into one of a multitude of output voltages. Each output from signal converter **51** corresponds to an individual manual switch on the digital camera, and has an output voltage which can be used to effectively activate the manual switch. Either a direct connection to the camera switch contact points can be made, thereby emulating the voltage that would appear had the switch been manually depressed, or the outputs from signal converter **51** can be used to control an actuator for physically closing the switch connection.

Controller **49** can be a programmable device such as a microprocessor, RISC processor, Field Programmable Gate Array (FPGA) or any other device known to those skilled in the art of control logic implementation for receiving , storing and replaying command scripts sent from the host processor and performing sequential operations in accordance with a programmed function. In the preferred embodiment a **PIC 17CXXX** series microcontroller is used due its small size, low power and adequate performance. Controller **49** is used to perform the rate conversion functions, Reed-Solomon coding, spread spectrum formatting and data buffering operations discussed previously. Other functions such as password verification, data encryption, image analysis, image processing, power management, autonomous phone dialing, event time logging and other ancillary functions can also be performed. Memory **50** is interfaced to and controlled by controller **49** for acquiring and storage of camera image data as well as other controller program functions which require memory. External event interface **52** is included to allow for external event triggers to activate camera functions in accordance with a corresponding program running on controller **49**. For example, an intrusion signal derived from an external

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detector can be used to initiate a command to take a photograph, automatically dial a phone number and forward the image for remote viewing.

FIG 5B illustrates a minimum controllerless configuration showing the functional blocks and signal path associated with remote digital camera being controlled directly from the communications link. The broken lines in the figure correspond to the components not used in this configuration. Correlator-B **47**, data latch-B **48** and signal converter **51** are only used if manual switch activation is required. The Largan digital camera in the preferred embodiment is completely controlled through its serial communications port and therefore does not require manual switch control.

FIG 5C is a block diagram showing a direct connection between the communications link and controller **49** without the use of the digital camera. This configuration is used to remotely pass script command sequences from the host to controller **49** and to forward image data previously stored in buffer **50** back to the host.

FIG 5D shows the components involved in the autonomous operation of the digital camera without use of the communications link. In this configuration, scripts from controller **49** are run for commanding the digital camera to take photographs at scheduled times or as triggered by external events through external event interface **52**.

FIG 5E shows the components used in conjunction with on-line processing operations interceding between the image data and communications forwarding function. As previously described, controller **49** in combination with memory **50** are used to perform rate conversion, error correction coding, image processing etc.

While the invention has been described with reference to certain preferred embodiments thereof, it is understood that the present disclosure has been made only by way of example and that various modifications and other embodiments thereof may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

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